

We claim:

1. An image defect inspection method for detecting
a gray level difference between the corresponding parts
of two images, comparing the detected gray level
5 difference with a threshold value, and judging the part
to be a defect when the gray level difference is larger
than the threshold value,

wherein cumulative frequencies of the
calculated gray level differences are calculated,
10 wherein converted cumulative frequencies
are calculated by converting the cumulative frequencies
so as to be linear with the gray level differences in a
predetermined distribution with which the gray level
differences are assumed to be distributed,

15 wherein a straight line approximation is
calculated by approximating the converted cumulative
frequencies to a straight line,

wherein a threshold value is determined
from a predetermined cumulative frequency based on the
20 calculated straight line approximation according to a
predetermined calculation method, and

wherein a comparison is made according to
the determined threshold value.

2. An image defect inspection method, as set forth
25 in claim 1, wherein the conversion of the cumulative
frequencies into the converted cumulative frequencies is
carried out by using a conversion table.

3. An image defect inspection method, as set forth
in claim 1, wherein the cumulative frequencies are
30 calculated from the sampled gray level differences.

4. An image defect inspection method, as set forth
in claim 1, wherein the threshold value is a gray level
difference corresponding to the value of the
predetermined cumulative frequency on the straight line
35 approximation plus a predetermined gray level difference.

5. An image defect inspection method, as set forth
in claim 1, wherein the gray level differences are

positive- or negative-signed data,

wherein the cumulative frequencies are
calculated from the signed corrected gray level
differences, and

5 wherein before the threshold value is
determined, two threshold values for the positive and
negative areas are determined.

6. An image defect inspection method, as set forth
in claim 1, wherein the gray level differences are
10 positive- or negative-signed data,

wherein the average of the signed gray
level differences is calculated,

wherein positive- or negative-signed
corrected gray level differences are calculated by
15 correcting the gray level differences with the calculated
average,

wherein absolute-value corrected gray
level differences without sign are calculated from the
signed corrected gray level differences,

20 wherein the cumulative frequencies are
calculated from the absolute-value corrected gray level
differences, and

wherein when a comparison with the
determined threshold value is made, the absolute-value
25 corrected gray level differences are compared with the
threshold value.

7. An image defect inspection method, as set forth
in claim 1, wherein the gray level differences are
positive- or negative-signed data,

30 wherein the cumulative frequencies are
calculated from the signed corrected gray level
differences,

wherein after two threshold values are
determined for the positive and negative areas, the
35 threshold value is determined as a corrected threshold
value, which is half of the difference between the two
threshold values for the positive and negative areas, and

wherein when a comparison is made, the absolute-value corrected gray level differences, which are the gray level differences corrected with the average of the two positive and negative threshold values, are compared with the threshold value.

8. An image defect inspection method, as set forth in claim 1, wherein correlation degrees of the gray level differences for plural types of distributions are calculated, respectively, and

wherein the threshold value determined from the distribution having the highest correlation degree is used.

9. An image defect inspection method, as set forth in claim 8, wherein the correlation degree is calculated from the difference between the converted cumulative frequencies and the straight line approximations after calculating the converted cumulative frequencies and the straight line approximations for the plural types of distributions, respectively.

10. An image defect inspection method, as set forth in claim 1, wherein plural individual threshold values are calculated for plural types of distributions, respectively, and

wherein the threshold value is determined as the average of the plural individual threshold values.

11. An image defect inspection method, as set forth in claim 1, wherein plural correlation degrees and plural individual threshold values of the gray level differences for plural types of distributions are calculated, respectively, and

wherein the threshold value is determined as the weighted average of the plural individual threshold values weighted by the plural correlation degrees.

12. An image defect inspection method, as set forth in claim 1, wherein the predetermined distribution is any one of a normal distribution, a Poisson distribution, a t

distribution, an exponential distribution, a Weibull distribution, or a chi-square distribution.

13. An image defect inspection method, as set forth in claim 1, wherein the determination of the threshold value is made automatically.

14. An image defect inspection apparatus comprising:

a difference image detection section for detecting a gray level difference between the corresponding parts of two images;

a defect detection section for comparing the detected gray level difference with a threshold value and judging the part to be a defect when the gray level difference is larger than the threshold value; and

a detection threshold value calculation section for changing the threshold value in accordance with the distribution of detected gray level differences, wherein the detection threshold value calculation section comprises:

a cumulative frequency calculation section for calculating cumulative frequencies of the calculated gray level difference;

a conversion section for calculating converted cumulative frequencies by converting the cumulative frequencies so as to be linear with the gray level differences in a predetermined distribution with which the gray level differences are assumed to be distributed;

a straight line approximation calculation section for calculating a straight line approximation by approximating the converted cumulative frequencies to a straight line; and

a threshold value determination section for determining a threshold value from the value of a predetermined cumulative frequency based on the calculated straight line approximation according to a predetermined calculation method, and

wherein a comparison is made according to the determined threshold value.

5 15. An image defect inspection apparatus, as set forth in claim 14, wherein the conversion section comprises a conversion table used to convert the cumulative frequencies into the converted cumulative frequencies.

10 16. An image defect inspection apparatus, as set forth in claim 14, wherein the cumulative frequency calculation section calculates the cumulative frequencies from the sampled gray level differences.

15 17. An image defect inspection apparatus, as set forth in claim 14, wherein the threshold value determination section determines a threshold value as a gray level difference of the point corresponding to the value of the predetermined cumulative frequency on the straight line approximation plus a predetermined gray level difference.

20 18. An image defect inspection apparatus, as set forth in claim 14, wherein the difference image detection section detects positive- or negative-signed gray level differences,

25 wherein the cumulative frequency calculation section calculates cumulative frequencies of the signed gray level differences, and

wherein the threshold value determination section calculates two threshold values for the positive and negative areas.

30 19. An image defect inspection apparatus, as set forth in claim 14, wherein the difference image detection section detects positive- or negative-signed gray level differences,

35 wherein said apparatus further comprises: an average calculation section for calculating the average of the signed gray level differences; a correction section for calculating positive- or negative-signed corrected gray level differences by correcting the

signed gray level differences with the calculated average; and an absolute-value conversion section for calculating absolute-value corrected gray level differences without sign from the signed corrected gray level differences, and

5 wherein the detection threshold value calculation section and the defect detection section carry out operations based on the absolute-value corrected gray level differences output from the absolute-value conversion section.

10 20. An image defect inspection apparatus, as set forth in claim 14, wherein the difference image detection section detects positive- or negative-signed gray level differences,

15 wherein the cumulative frequency calculation section calculates cumulative frequency of the signed gray level differences,

 wherein the threshold value determination section first calculates two threshold values for the positive and negative areas then determines half of the difference between the two positive and negative values for the positive and negative areas as a corrected threshold value,

20 wherein said apparatus further comprises an average operation section for calculating the average of the two positive and negative threshold values,

25 wherein the image defect detection apparatus further comprises a correction section for calculating absolute-value corrected gray level differences by correcting the signed gray level differences with the average of the two positive and negative threshold values, and

30 wherein the detection threshold value calculation section and the detection section carry out operations based on the absolute-value corrected gray level differences output from the correction section.

35 21. An image defect inspection apparatus, as set

forth in claim 14, wherein the detection threshold value calculation section further comprises a correlation degree calculation section for calculating correlation degrees of the gray level differences for plural types of distributions, respectively, and

wherein the detection threshold value calculation section determines the threshold value from the distribution having the highest correlation degree.

22. An image defect inspection apparatus, as set forth in claim 14, wherein the conversion section and the straight line approximation calculation section of the detection threshold value calculation section calculate the plural converted cumulative frequencies and the plural straight line approximations for plural types of distributions, respectively,

wherein the detection threshold value calculation section further comprises a correlation degree calculation section for calculating correlation degrees of the gray level differences for the plural types of distributions from the difference between the plural converted cumulative frequencies and the plural straight line approximations, respectively, and

wherein the threshold value determination section of the detection threshold value calculation section determines a threshold value based on the straight line approximation having the highest correlation degree.

23. An image defect inspection apparatus, as set forth in claim 14, wherein the detection threshold value calculation section calculates plural individual threshold values for plural types of distributions, respectively,

wherein said apparatus further comprises a threshold value average calculation section for calculating the average of the plural individual threshold values, respectively, and

wherein the threshold value determination

section determines the average of the plural individual threshold values calculated by the threshold value average calculation section as the threshold value.

24. An image defect inspection apparatus, as set forth in claim 14, wherein the detection threshold value calculation section determines the threshold values for plural types of distributions, respectively,

wherein the detection threshold value calculation section further comprises a correlation degree calculation section for calculating correlation degrees of the gray level differences for plural types of distributions, respectively, and a weighted average threshold value calculation section for calculating the weighted average of the plural individual threshold values by weighting them with the plural correlation degrees, and

wherein the weighted average calculated by the weighted average threshold value calculation section is determined as the threshold value.

20 25. An image defect inspection apparatus, as set forth in claim 14, wherein the conversion section carries out a conversion using any one of a normal distribution, a Poisson distribution, a t distribution, an exponential distribution, a Weibull distribution, or a chi-square
25 distribution as the fixed distributions.

26. An appearance inspection apparatus for detecting a defect of a semiconductor circuit pattern formed on a semiconductor wafer, comprising an image pickup means for generating the image of the semiconductor circuit pattern on the semiconductor wafer and the image defect inspection apparatus set forth in claim 14, wherein the image defect inspection apparatus detects a defect of the semiconductor circuit pattern.

27. An image defect inspection method for detecting
a gray level difference between the corresponding parts
of two images, comparing the detected gray level
difference with a threshold value, and judging the part

to be a defect when the gray level difference is larger than the threshold value,

wherein the gray level differences are positive- or negative-signed data,

5 wherein the average of the signed gray level differences is calculated,

wherein signed corrected gray level differences are calculated by correcting the gray level differences with the calculated average,

10 wherein absolute-value corrected gray level differences without sign are calculated from the signed corrected gray level differences, and

wherein the absolute-value corrected gray level differences are compared with the threshold value.

15 28. An image defect inspection apparatus comprising:

a difference image detection section for detecting a gray level difference between the corresponding parts of two images; and

20 a defect detection section for comparing the detected gray level difference with a threshold value and judging the part to be a defect when the gray level difference is larger than the threshold value,

25 wherein the difference image detection section detects positive- or negative-signed gray level differences,

wherein said apparatus further comprises:
an average calculation section for calculating the average of the signed gray level differences; a
30 correction section for calculating signed corrected gray level differences by correcting the signed gray level differences with the calculated average; and an absolute-value conversion section for calculating absolute-value corrected gray level differences without sign from the
35 signed corrected gray level differences, and

wherein the defect detection section compares the absolute-value corrected gray level

differences with the threshold value.

29. An image defect inspection method for detecting
a gray level difference between the corresponding parts
of two images, comprising the detected gray level
5 difference with a threshold value, and judging the part
to be a defect when the gray level difference is larger
than the threshold value,

wherein the gray level differences are
positive- or negative-signed data,
10 wherein positive and negative cumulative
frequencies are calculated from the gray level
differences,

wherein two threshold values are
determined for the positive and negative areas from the
15 cumulative frequencies according to a predetermined
calculation method and half of the difference between the
two positive and negative threshold values is determined
as a corrected threshold value,

wherein absolute-value corrected gray
20 level differences are calculated by correcting the gray
level differences with the average of the two positive
and negative threshold values,

wherein an absolute-value threshold value
is calculated from the two positive and negative
25 threshold values, and

wherein the absolute-value corrected gray
level differences are compared with the absolute-value
threshold value.

30. An image defect inspection apparatus
30 comprising:

a difference image detection section for
detecting a gray level difference between the
corresponding parts of two images; and

a defect detection section for comparing
35 the detected gray level difference with a threshold value
and judging the part to be a defect when the gray level
difference is larger than the threshold value,

wherein the difference image detection section detects positive- or negative-signed gray level differences,

5 wherein said apparatus comprises: a
cumulative frequency calculation section for calculating
positive and negative cumulative frequencies from the
gray level differences; a threshold value determination
section for determining two threshold values for the
positive and the negative areas from the cumulative
10 frequencies according to a predetermined calculation
method; a corrected threshold value determination section
for determining a corrected threshold value by
calculating half of the difference between the two
positive and negative threshold values; an absolute-value
15 corrected gray level calculation section for calculating
absolute-value corrected gray level differences by
correcting the gray level differences with the average of
the two positive and negative threshold values; and an
absolute-value threshold value calculation section for
20 calculating an absolute-value threshold value from the
two positive and negative threshold values, and

 wherein the defect detection section
compares the absolute-value corrected gray level
differences with the absolute-value threshold value.